Lower Delaware River Eligibility Determination for DRBC Declaration of Special Protection Waters

Delaware River Basin Commission
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Lower Delaware River Eligibility Determination for DRBC Declaration of Special Protection Waters

Introduction

On November 19, 1999, the U.S. Senate passed S. 1296, the Lower Delaware Wild and Scenic Rivers Act. Congress passed the bill in October 2000 (see **Appendix A**), designating segments of the study area as a recreational river, to be managed in accordance with the Lower Delaware River Management Plan. On November 1, 2000, the President of the United States signed the Act. Federal Wild and Scenic designation now covers most of the 197-mile non-tidal portion of the Delaware River. Wild and Scenic status serves a basic requirement in Delaware River Basin Commission (DRBC) rules for declaration of the higher of two Special Protection Waters (SPW) protection levels: Outstanding Basin Waters (OBW). The lower protection level, Significant Resource Waters (SRW), may be declared for any water body meeting SPW criteria.

The DRBC Lower Delaware Monitoring Program (LDMP) operates in support of the Lower Delaware River Management Plan, produced by the Lower Delaware River Wild and Scenic River Study Task Force and the National Park Service (1997). Goals of the Management Plan are shown in the text box on the next page. The first goal of the Management Plan is to "**maintain existing water-quality (EWQ) in the Delaware River and its tributaries from measurably degrading and improve it where practical.**"

The "maintain EWQ" objective requires Special Protection Waters status in order for anti-degradation policy to take effect in DRBC water quality standards. On January 28, 1998, the DRBC passed Resolution No. 98-2, which endorsed the Lower Delaware River Management Plan and resolved to "…take such action as it deems appropriate to implement the goals of the plan commensurate with available resources." DRBC staff interpreted this to mean that DRBC should manage water quality to prevent degradation where EWQ is cleaner than standards and to improve water quality where it does not meet standards. In areas of good water quality, requirements include setting and agreeing on permitting standards for discharges as well as providing tools and information that will prevent additional impacts from land development and for management activities. "Keeping clean water clean" is a major challenge in areas such as the Lower Delaware where increased growth and development activity are expected. Where standards are not being met for designated uses, regulatory and non-regulatory strategies must be developed to identify pollutant sources and to achieve the standards.

The National Park Service (1999) surveyed river-corridor landowners, finding significant support for river corridor protection. 98% felt that water quality should be preserved, and 90% support land use regulations and programs to preserve and protect the river.

Water Resources Plan for the Delaware River Basin

In June 2004, DRBC issued the Water Resources Plan for the Delaware River Basin (Basin Plan). The Basin Plan was created through the efforts of numerous agencies, organizations, industries, and other interested parties of the Delaware Basin. A Watershed Advisory Council composed of these interests provided overall Basin Plan direction, and agreed that water quality conditions must be monitored with sufficient frequency in the main stem and the tributaries to track water quality maintenance, improvement, or degradation. Under Basin Plan goals relating to meeting ecosystem, recreational, and off stream water needs, specific objectives of the Basin Plan include:

1. Where water quality meets or is better than standards for the protection of aquatic and wildlife, off stream uses, or recreational needs, implement anti-degradation regulations, policies and/or other mechanisms to maintain or improve existing water quality.

2. Where water quality is not sufficient to protect aquatic life and wildlife, off stream uses, or recreational needs, employ strategies to provide protection through the implementation of Total Maximum Daily Loads (TMDL) and other regulatory and non-regulatory means.

According to the Basin Plan, approaches may include: 1) Anti-degradation programs (e.g. state protections for high quality and exceptional value streams, the DRBC's Special Protection Water designations and federal Wild and Scenic Rivers designations); 2) Stormwater management programs; 3) Water quality-based trading programs (offsetting impacts from new or expanded discharges by equivalent or greater reductions from other sources within the watershed).

Lower Delaware River Management Plan Goals

National Wild and Scenic Study Report (NPS 1999, p. 59-60)

Goal 1: Water Quality
Maintain existing water quality in the Delaware River and its tributaries from measurably degrading and improve it where practical.

Policies:

- Achieve the highest practical state and federal water quality designation for the river and its tributaries.
- Manage point discharge and storm water non-point runoff to minimize degradation of the river.
- Encourage the use of Best Management Practices in the agricultural areas within the river corridor to minimize water quality degradation from storm water runoff.
- Encourage the use of Best Management Practices for activities other than agriculture that could result in water quality degradation from storm water runoff.
- Discourage inappropriate development in floodplains, wetlands, steep slopes and buffer strips along the lower Delaware River and its tributaries.

Implementation Strategies:

General

- Pennsylvania DEP, New Jersey DEP, and the Delaware River Basin Commission should jointly develop a river corridor water quality management plan describing the highest level of water quality protection consistent with the water quality goal of this management plan, and the monitoring, research, modeling and regulations needed to insure protection of that level of water quality.
- An enhanced water quality monitoring program should be implemented for the lower Delaware River and its tributaries under the leadership of the Delaware River Basin Commission.
- The regional cooperative environmental monitoring plan prepared for the Delaware Estuary Program should be expanded and adopted to cover the entire river corridor. The environmental monitoring plan is focused on the key areas of water quality, toxics, living resources, and habitat/land cover/land use.
- The current system of monitoring septic/sewage systems should be improved and property owners should be educated.
- Public education programs to protect water quality.
- The NRCS and states should encourage farmers to develop farm management plans in accordance with Best Management Practices.
- Periodic water quality announcements and/or advisories should be issued by DRBC.

Delaware Riverkeeper Petition

In April 2001, the Delaware Riverkeeper Network, an affiliate of the American Littoral Society, petitioned the DRBC to classify the Lower Delaware River as Special Protection Waters. DRBC staff replies to the petition are shown in **Appendix B**. The petitioner specifically asked:

1. That the entire reach of Delaware River main stem from River Mile 209.5 (downstream boundary of the Delaware Water Gap National Recreation Area) to River Mile 133.4 (Head of Tide) be designated as a Special Protection Water;

2. That those sections of the proposed Special Protection Waters that are now components of the National Wild and Scenic Rivers System due to the enactment of Public Law 106-418 cited as the "Lower Delaware Wild and Scenic Rivers Act", be classified by the Commission as Outstanding Basin Waters;

3. That those sections of the proposed Special Protection Waters that are not components of the National Wild and Scenic Rivers System be classified by the Commission as Significant Resource Waters;

4. That the Commission adopt the Lower Delaware River Management Plan, as cited in Public Law 106-418 and dated August 1997, into its Comprehensive Plan as provided for in Compact Section 3.1;

5. That the Commission, in cooperation with the States of New Jersey and Pennsylvania, initiate the development of the bi-state water quality management plan called for in the Lower Delaware River Management Plan, said plan to be focused on preserving and/or improving existing water quality;

6. That the Commission make the development of the bi-state water quality management plan for the Lower Delaware River a specific and high priority task of its pending Comprehensive Planning activity; and

7. That the Commission adopt interim measures during the third quarter of 2001 that protect existing water quality from changing in the Lower Delaware while all necessary planning is being conducted. These measures should include interim definitions of existing water quality derived from all currently available data and effluent requirements based upon Best Demonstrable Treatment technology or facsimile as defined in the Special Protection Waters regulations.

Furthermore, the petitioner requested:

8. That the Commission comply with Section 3.10.3A.2e.3) of its regulations. This section of the Commission's water quality standards required the Commission to prioritize watersheds in the currently designated Special Protection Waters drainage area (Middle and Upper Delaware) by February 1996. The petitioner noted that this deadline was not met. Priority watersheds are watersheds where non-point source control plans were to be developed by the Commission no later than 2001. This deadline was not met either. The petitioner suggested that the February 1996 deadline be extended by Commission action to a date in 2003 that corresponds to the release of a draft new or updated Comprehensive Plan and that said plan contain the information and recommendations required by Section 3.10.3A.2e.3).

9. That the Commission prioritize the watersheds draining to the Lower Delaware River simultaneously with its prioritization of upper basin watersheds. This prioritization is necessary for the development of the bi-state water quality management plan as described above. Moreover, performing the prioritization activity as part of an overall Comprehensive Planning process insures that all future activities are directed at the highest priorities.

Lastly, the petitioner suggested:

10. That the Commission's Comprehensive Planning program consider using the Special Protection Waters boundary and interstate control point approach as its basic framework for developing policies and managing all water resource issues in the Basin – to the extent applicable. The control point approach establishes specific goals, objectives, and measures of success on an individual watershed and location basis as well as at Basin level. This allows specific goals and objectives to be established, distinct priorities and activities to be developed, and explicit actions to be assigned to specific organizations and agencies rationally within an overall Delaware River Basin planning context.

Special Protection Waters Eligibility Determination

When the Delaware Riverkeeper petitioned DRBC in 2001, no immediate water quality determination could be made because of very limited data availability. Analysis of the historical monitoring network revealed that the data record was insufficient to describe the status and trends of Lower Delaware River water-quality, and without more data, existing water quality could not be numerically defined. Refer to the technical water

quality report "Lower Delaware Monitoring Program: 2000-2003 Results and Water Quality Management Recommendations " (DRBC 2004) for detailed water quality results of the Lower Delaware Monitoring Program. The report describes creation of the LDMP monitoring network based upon the Control Point Approach, and presents results of four years of a five-year monitoring effort. It also describes initial year 2001 results of the Delaware River Biomonitoring Program, under which DRBC monitors benthic macroinvertebrates and river habitat conditions for the entire non-tidal portion of the Delaware River.

What is Existing Water Quality?

Traditionally and historically, water quality standards and criteria have been developed to protect certain uses of the water resource. Conventional numeric criteria have been oriented toward effect levels upon these uses, where negative effects upon human health, aquatic life, recreation, or suitability for water supply are likely to occur. There is a gap in water resource protection created by this approach. Poole et al. (2004) determined that while conventional standards have proved valuable, regime-based standards are better structured to address human caused imbalances in dynamic, natural water quality. In very high-quality waters, typical concentrations of water quality constituents are far better than effect levels. EWQ is the typical range of concentration levels of all measurable constituents of ambient waters, as defined over a specific time period. EWQ is defined either by design or by summary of historical data, and these water quality levels are used in combination with antidegradation policies to protect water quality. The main objective of such "no measurable change" policy is to protect defined water quality from degrading from current high quality levels.

Declaration of Special Protection Waters by DRBC is a major statement of antidegradation policy, or a declaration of intent that the waters of the Delaware shall be managed to maintain water quality at EWQ levels and not allow change toward effect-level criteria or worse. Of course, natural water quality may vary widely throughout the course of the day and the season, so monitoring must be as comprehensive as practicable so that the natural range of variation is captured. Once sufficient data are collected to describe EWQ with confidence, the natural range of EWQ is statistically expressed either non-parametrically in terms of median, 10^{th} and 90^{th} percentiles; or parametrically in terms of mean and 95% confidence limits. Once EWQ is defined, the monitoring focus then shifts to determine whether water quality is changing (and why) over time using the statistically expressed range of variability to detect "measurable change."

Development of Measurable Indicators from DRBC Narrative Rules

In order to determine eligibility of the Lower Delaware River for Special Protection Waters status, "**evidence must be shown that these waters are considered to have exceptionally high scenic, recreational, ecological, and/or water supply values"** (DRBC Water Quality Standards, 1996).

In DRBC water quality regulations, the rule language provides no quantitative criteria to judge "exceptionally high" values. Measurable indicators for SPW determination were derived by parsing the statement from DRBC rules into measurable component parts. As the focus of this investigation, water quality was measured in terms of ecological, recreational, and water supply values. As an indicator of "exceptionally high" value, water quality was compared with the most stringent criteria chosen from among DRBC, Pennsylvania, or New Jersey water quality standards. Water quality of the river was also compared with that of designated EV, HQ, or C1 waters. Federal guidelines were used where no criteria exist. For ecological value, further consideration was given to measures of biological integrity. Measurable biological traits include taxonomic richness, diversity, balance, pollution intolerance and physical habitat value.

Scenic and recreational values are discussed at length in the Lower Delaware Management Plan (1997) and the National Park Service Lower Delaware Wild and Scenic Study (1999) as federal designation categories judged under specific criteria. Selections are presented in **Appendix C**. The Lower Delaware River offers a variety of recreational uses which include boating, fishing, canoeing, tubing, swimming, wildlife watching and tourism at numerous historical and cultural sites along the river. Visitors to the Delaware Water Gap National

Recreation Area at the head of the Lower Delaware exceed 4.5 million per year and partake in activities along and in the Delaware. Recreational use along the Lower Delaware River is substantial. On hot summer days, the canoe liveries send hundreds of canoes and tubes on day trips. An average season for these liveries provides access to 15,000 people per livery (Bucks County River Country, personal communication 2004). Delaware River Biomonitoring Program observers (unpublished DRBC field notes, 2001-2003) typically recorded about 40 boats, canoes, tubes or waders per hour passing Lower Delaware biomonitoring sites, but flotillas of up to 220 per hour have been noted. This is in addition to the substantial number of people who enjoy the river along the numerous public access points. Fishing pressure is heavy, particularly when the American Shad and River Herring are running in the spring. The Shad Festival at Lambertville, NJ and New Hope, PA with attendance over the two day festival exceeding 30,000 people, centers upon the annual return of these migratory species. Events like this are culturally and economically significant to the region where river centered recreation and tourism is of increasing economic importance. Opportunities abound for wildlife watching. DRBC staff commonly note the presence of snakes, turtles, salamanders, otters, bears, deer, hawks, owls, osprey, bald eagles, herons, egrets, and many types of songbirds. River-centered recreation and tourism is of increasing economic importance, and its resource value must be protected.

In terms of ecological value, the river's geological variety and flow regime provide suitable and heterogeneous habitat for a diverse, rich and abundant aquatic community. The Lower Delaware is a generally wide, shallow, gravel and cobble-bottom river that flows through a very diverse landscape. Geological features such as the Piedmont's Triassic Rock outcrops and boulder-field remnants of two glaciers, combined with numerous islands, riffles, pools, aquatic vegetation beds, back-channels, and forested riparian canopy provide a wide range of habitat types for biological activities such as feeding, reproduction and refuge. The Delaware River's continuity of diverse habitat is much reduced or absent in nearly all other large rivers of the eastern U.S., where dams, levees, and channelization have fragmented the river continuum. The free-flowing nature of the Delaware River is unique and exceptional. The Delaware River Biomonitoring Program has sampled habitat and benthic macroinvertebrates since 2001, and early results are quite positive. All of the first year samples have shown that the benthic assemblage is rich, diverse, well balanced, and intolerant of pollution – scoring as well as or better than the Special Protection Waters of the Middle and Upper Delaware. DRBC and USGS river biologists find that a high-quality biological community exists in the Lower Delaware River, which also indicates high water quality.

As additional evidence of the ecological value of the Lower Delaware, **Appendix C** contains selections from the Lower Delaware National Wild and Scenic Study Report (NPS, 1999). Natural resource values of the Lower Delaware have been recognized and designated by the states and the federal government. These include geological features, vegetation and critical habitat, fisheries, wildlife, Delaware River islands, and wetlands.

Under Pennsylvania DEP water quality standards, the Lower Delaware is classified as a Warm Water Fishery. Warm water fishes such as bass, perch, white suckers and many other species are abundant year-round; and the fish community is supplemented annually by major migrations of American Shad, American Eel, and River Herring. Owing to its free-flowing character and good water quality, the Delaware River is a major sport-fishing draw for anglers who seek these migratory species. Fisheries provide economic and quality of life benefits to the region.

Water supply value may be the most critical and vulnerable resource issue relevant to SPW designation. The Lower Delaware certainly can be described as an exceptional value water supply resource. Sayers (personal communication, 2004) related that as of 2004, an estimated 2.9 million people directly depend upon water supplied by the Lower Delaware. Public water supply withdrawals taken directly from the Lower Delaware River total 131.6 million gallons per day. These public water suppliers serve 1.1 million customers:

City of Easton;
North Penn and North Wales Water Authorities, via the Point Pleasant water diversion;
New Jersey Water Supply Authority, via the Delaware and Raritan Canal diversion;

Pennsylvania American Water Company, Yardley District;
Morrisville Borough; and
Trenton Water Works.

Industrial and power generation water supply is also significant within the Lower Delaware. Chief among these in water use are four major power generation facilities: Portland, Martins Creek, Gilbert, and Limerick Nuclear, which is also fed by the Point Pleasant Diversion. Every river town contains some industry, though this use of the water resource is not as intensive as in years past.

Additional downstream water suppliers are also dependent upon water quality of the Lower Delaware as freshwater inflow to the upper Delaware Estuary. Downstream withdrawals total 219.8 million gallons per day, serving about 1.8 million people. Customers of the Philadelphia Water Department; Lower Bucks County Joint Municipal Authority; New Jersey American Water Company Delran Intake; Bristol Borough and Burlington City are dependent upon fresh and clean water that flows through the Lower Delaware.

Control Point Monitoring Concepts

Historical DRBC monitoring programs have been designed for very specific purposes, such as the 1987 and 1999 bacteria surveys for primary contact recreation suitability assessment, or synoptic surveys used for the 305b assessment to determine compliance with water quality standards. The design of the LDMP is different in that the results are expected to be used not only for compliance with standards, but also to create targets for protection of existing water quality. Such management includes:

- Establishment of baseline EWQ for future comparison;
- Setting targets for maintenance of water quality where standards are met;
- Setting targets for improvement of water quality where standards are not met;
- Setting geographic and water quality priorities to meet the targets; and
- Monitoring long-term so that DRBC can consistently perform its 305b assessment, monitor trends, prioritize agency management activities, and assess effectiveness of strategy implementation.

In order to meet these purposes, the design was created to address some questions about the Lower Delaware:

- How does water quality change from the Delaware Water Gap to Trenton?
- Which tributaries produce such changes?
- Where should restoration or protection resources be devoted for water quality benefit?

Certain terms are associated with the way DRBC evaluates water quality data. Since DRBC evaluates its data along the geographical boundaries of a longitudinal river corridor, it is necessary to segment the river so that changes from upstream to downstream can be documented at particular locations. The points on the Delaware River where changes to water quality are assessed are known as **Interstate Control Points (ICP)**, since these are located along the river which is the boundary between states. Delaware River bridges are typical locations of ICP sites, chosen for reasons of safety, economy, and ease of access. Interstate Control Points are placed between major inputs of water to the Delaware River. A common approach to impact assessment for water resource scientists is the "upstream-downstream" evaluation, where water quality is assessed upstream of an input or point source, at the point source itself, and the combined effect is assessed downstream of the confluence of the upstream and point source inputs. Each tributary is considered a discrete input or point source to the Delaware River. The LDMP monitors these **Boundary Control Points (BCP)** near to their confluence but away from backwater influence of the Delaware River. To evaluate the effects of each tributary upon the Delaware River, it is necessary to monitor the tributary BCP and to relate the resulting information to the nearest upstream and downstream ICP. **Table 1** lists LDMP ICP and BCP sites where existing water quality was defined using the 2000-2003 data set.

Any criteria or targets created using the control point approach are site-specific. Site-specific targets can be monitored at a high accuracy level with the ability to detect water quality changes. In addition, the control point approach allows for creation of watershed-specific water quality targets, where effects of each tributary upon the river are differentiated and requirements for maintenance or restoration of water quality can be modeled and quantified. The site-specific control point approach has advantage over the reach-wide target approach in current DRBC rules in that if measurable change in the Delaware River or tributary is detected, it is possible to determine the source of change and take appropriate action at smaller relative cost and effort.

Table 1. Lower Delaware Monitoring Program ICP and BCP Sites

Site Name	River Mile	Drainage Area (mi2)	Control Point Type	State Designated AntiDegradation Waters	Physiographic Province
Delaware River at Portland Footbridge	207.40	4,165.0	Interstate CP	-----	Valley/Ridge
Paulins Kill, Warren Co., NJ	207.00	177.0	Tributary BCP (major)	-----	Valley/Ridge (limestone)
Delaware River at Belvidere Bridge	197.84	4,378.0	Interstate CP	-----	Valley/Ridge
Pequest River, Warren Co., NJ	197.80	157.0	Tributary BCP (major)	-----	Valley/Ridge (limestone)
Martins Creek, Northampton Co., PA	190.80	45.5	Tributary BCP (major)	-----	Valley/Ridge (limestone)
Bushkill Creek, Northampton Co., PA	184.10	80.0	Tributary BCP (major)	PA HQ-CWF	Valley/Ridge (limestone)
Delaware River at Easton, PA.	183.82	4,717.0	Interstate CP	-----	Valley/Ridge
Lehigh River, Northampton Co., PA	183.66	1,364.0	Tributary BCP (major)	-----	Valley/Ridge
Pohatcong Creek, Warren Co., NJ	177.40	57.1	Tributary BCP (major)	NJ C1	Valley/Ridge
Delaware River at Riegelsville Bridge	174.80	6,328.0	Interstate CP	-----	Valley/Ridge
Musconetcong River, Wrrn/Hntdn Co., NJ	174.60	156.0	Tributary BCP (major)	-----	Valley/Ridge
Cooks Creek, Bucks Co., PA	173.73	29.5	Tributary BCP (major)	PA EV	Valley/Ridge
Delaware River at Milford Bridge	167.70	6,381.0	Interstate CP	-----	Piedmont
Nishisakawick Creek, Hunterdon Co., NJ	164.10	11.1	Tributary BCP (minor)	NJ C1	Piedmont
Tinicum Creek, Bucks Co., PA	159.90	24.0	Tributary BCP (minor)	PA EV	Piedmont
Tohickon Creek, Bucks Co., PA	157.00	112.0	Tributary BCP (major)	-----	Piedmont
Paunacussing Creek, Bucks Co. PA	155.60	7.9	Tributary BCP (minor)	PA HQ-CWF	Piedmont
Delaware River at Bulls Island Footbridge	155.40	6,598.0	Interstate CP	-----	Piedmont
Lockatong Creek, Hunterdon Co., NJ	154.00	23.2	Tributary BCP (minor)	NJ C1	Piedmont
Wickecheoke Creek, Hunterdon Co., NJ	152.50	26.6	Tributary BCP (minor)	NJ C1	Piedmont
Delaware River at Lambertville Bridge	148.70	6,680.0	Interstate CP	-----	Piedmont
Pidcock Creek, Bucks Co., PA	146.30	12.7	Tributary BCP (minor)	-----	Piedmont
Delaware River at Washington's Crossing	141.80	6,735.0	Interstate CP	-----	Piedmont
Delaware River at Calhoun St. Bridge	134.34	6,780.0	Interstate CP	-----	Piedmont

In the Lower Delaware scenic rivers legislation, there are undesignated gaps between the designated river segments of the Lower Delaware (**Figure 1**). These are typically river segments located in the vicinity of urban and industrial centers, where such uses as industrial supply and water supply are important. It is not possible to allow water quality degradation in undesignated segments without expecting water quality to degrade in designated segments. For consistent management, antidegradation policy must be applied without regard to artificial or political boundary lines along the longitudinal corridor. For this reason, the control point approach was not created to be consistent with federal scenic rivers-designated segments described in the legislation.

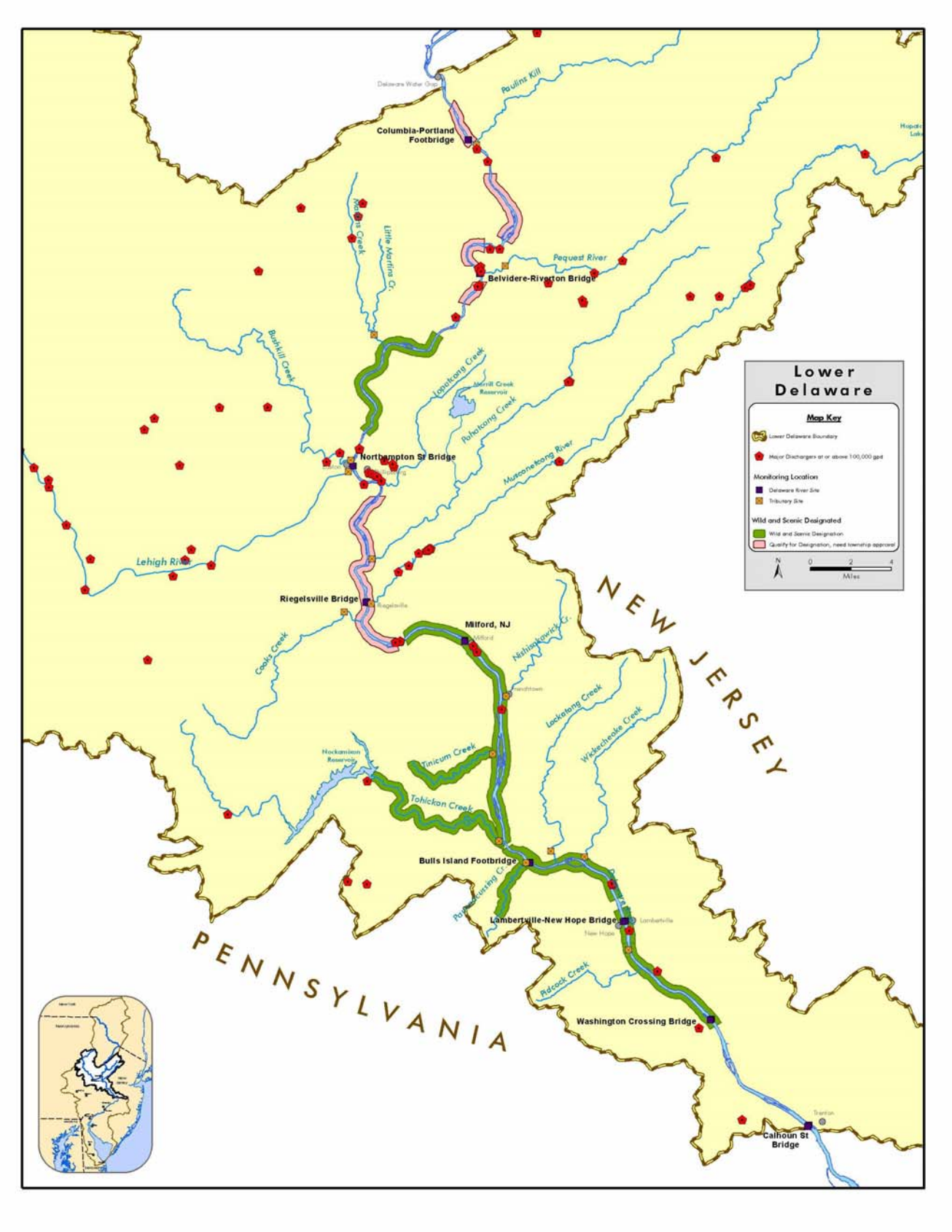

Figure 1. Lower Delaware Scenic River Segments, Dischargers, and Monitoring Locations.

State and federal program managers have agreed with the control point approach and site-specific, quantitative water quality targets. During program design, NJ and PA state agency representatives on the LDMP Technical Advisory Committee noted their utility for state monitoring and management planning.

The control point approach should result in efficient management of water quality. If a problem is detected at an ICP site but not at its upstream neighbor site, it is simpler to intensively survey a 10-mile reach than a 75-mile reach. Once BCP targets are created, they will provide measurable targets for state managers to fund projects in priority watersheds and to quantify water quality effects of completed restoration or protection projects. BCP and ICP existing water quality targets can also be used in combination with long term monitoring to improve agency reaction time for abatement of water quality degradation. Presently, correction of effect-level criterion violations is often an economically burdensome effort to improve degraded water quality. Note state experiences with Total Maximum Daily Loads (TMDL) as illustration of this point. Rarely, if ever, are water quality improvements realized to levels that are better than minimally acceptable standards. Use of BCP and ICP targets should enable more rapid and inexpensive response to water quality changes before a TMDL becomes necessary. Thus, water quality corrections may be realized before it's too late to act on a small scale; and before water quality degrades from very good to minimally acceptable. Existing Water Quality thus becomes a tool to measure water quality relative to the water quality standards. If water quality improves, EWQ targets can be periodically upgraded to realize long-term water quality improvement.

Based upon the LDMP 2000-2003 data set, existing water quality was defined at each of 9 ICP monitoring locations and compared with the most stringent criteria available. **Table 2** describes how EWQ fared versus criteria at each location and for each parameter monitored. Detailed results are described in the accompanying technical water quality report "Lower Delaware Monitoring Program: 2000-2003 Results and Water Quality Management Recommendations " (DRBC 2004).

In addition, Lower Delaware biological metrics were calculated from the 2001 biological data set and compared with the most stringent targets from the Upper Delaware Special Protection Waters and with New Jersey's criterion for definition of a pollution intolerant macroinvertebrate assemblage. The DRBC's Delaware River Biomonitoring Program gathers sufficient physical, chemical, and biological information to serve the following purposes:

- Implement SPW regulations for the Upper and Middle Delaware River.
- Define EWQ and implement anti-degradation protection of the Lower Delaware River.
- Develop a Benthic Index of Biological Integrity (B-IBI) for the non-tidal Delaware River.
- Provide biological assessment information for the Delaware River 305B report.
- Increase the base of ecological knowledge of large free-flowing rivers.

Eligibility Determination

Does the Lower Delaware meet DRBC or State water quality standards?

Delaware River results indicate that existing water quality is better than criteria levels, with the exception of bacteria. Of 153 possible comparisons of EWQ to most stringent criteria (9 ICP sites, 17 parameters), 94% showed that EWQ is better than criteria.. 74% were better at all times, 20% met criteria about 90% of the time, and 6% never met criteria. For most sites and parameters, EWQ based targets would provide protection for maintenance of existing good water quality. Enterococcus bacteria concentrations are the single major problem. Fecal coliform and E. coli bacteria concentrations were problematic during storms. Phosphorus concentrations were relatively high but did not render the Lower Delaware unsuitable for aquatic life use. At certain locations, pH and TDS were naturally divergent from criteria levels, indicating that perhaps the criteria themselves need revision. As shown in **Table 2**, EWQ targets will provide additional water quality protection by establishing targets for 10 more parameters without currently established criteria.

EWQ Better	EWQ is better than criteria
EWQ Better Except for High Flow	EWQ is better than criteria except during high flow events (E. coli, Fecal coliform bacteria)
Criteria exceeded by natural conditions	EWQ is evidenced to be naturally higher than criteria (TDS, pH)
TP criterion exceeded but use not limited	EWQ higher than NJ 0.1 criterion, but suitable for designated uses (Total Phosphorus)
EWQ Exceeds Criteria	EWQ Exceeds Criteria for >10% of Samples
Not Assessed	Not Assessed

Parameter	Del @ Portland	Del @ Belvidere	Del @ Easton	Del @ Riegelsville	Del @ Milford	Del @ Bulls Island	Del @ Lambertville	Del @ Washington Xing	Del @ Trenton	Most Stringent Criterion
Bio - EPT (N=1)										UPDE EWQ
Bio - HBI (N=1)										NJ 4.0
Bio - Diversity (N=1)										UPDE EWQ
Dissolved Oxygen										5 (all)
pH										6.5-8.5 (NJ)
Water Temperature F										Seasonal (PA)
Turbidity										15 (NJ)
CaCO3 Alkalinity										Min 20 (PA)
Chloride										250 (all)
Nitrate NO3-N										10 (PA,NJ)
Ammonia NH3-N										Formula (PA,NJ)
Total Phosphorus										0.1 (NJ)
Total Dissolved Solids										120/256 (DRBC)
Total Suspended Solids										40 (NJ)
E. coli geometric mean										126 (EPA)
Fecal Coliform geometric mean										200,400 (all)
Enterococcus geometric mean										33,61 (NJ)
Biocriteria	**NO STANDARD**			**EWQ definition would create targets for parameters without standards**						None
CaCO3 Hardness	**NO STANDARD**									None
Chlorophyll A mg/m3	**NO STANDARD**									None
Dissolved Oxygen % Saturation	**NO STANDARD**									None
Orthophosphate PO4-P	**NO STANDARD**									None
Phytoplankton Biomass mg/m3	**NO STANDARD**									None
Specific Conductance umhos/cm	**NO STANDARD**									None
Total Nitrogen : Total Phosphorus ratio	**NO STANDARD**									None
Total Kjeldahl Nitrogen	**NO STANDARD**									None
Total Nitrogen	**NO STANDARD**									None

Table 2. Lower Delaware River Existing Water Quality (2000-2003) vs. Most Stringent Water Quality Criteria.

How much better is EWQ than criteria?

DRBC's Integrated Listing Methodology (2004) identified key water quality parameters associated with each designated use being assessed in the non-tidal Delaware River:

Recreation: Fecal coliform (col/100ml)
Water Supply: TDS; Turbidity; Chloride mg/l
Aquatic Life: DO; pH; Water Temp; TDS; Alkalinity; Turbidity

The assumption was made that if criteria are met for parameters associated with designated uses, then the designated use is met. Perception of water quality in the Delaware River and its tributaries is dependent on the perspective of the designated use being examined.

Key parameters for the uses designated for Delaware River Zones 1D (north of the Lehigh River) and 1E (south of the Lehigh River) are better than criteria. According to integrated listing methods, the Water Supply and Aquatic Life designated uses are met, and existing water quality is much better than criteria for all of the key parameters associated with these uses. Even fecal coliform bacteria concentrations (the only bacteria

parameter for which DRBC has standards) meet the primary contact Recreation use most of the time. In the Delaware River, seasonal geometric mean fecal coliform concentrations were well below the criterion of 200 colonies per 100 ml. Fecal coliform bacteria problems become evident only when results show that the single-sample maximum limit of 400 colonies per 100 ml is exceeded in more than 10% of samples. High-flow events explain almost all occurrences of criteria violations. This infers that it is safe to swim in the Delaware River at most times except for storm conditions. It is recommended for purposes of policy and program management that if existing water quality is better than standards, then water quality should be prevented from degrading below EWQ levels. SPW declaration would provide such water quality protection.

Some criteria could directly serve as EWQ targets, as natural EWQ is close to criteria levels: turbidity, alkalinity, pH, and water temperature. Other criteria are far higher than EWQ, as in the case of chloride, where the criterion level is 250 mg/l to protect human health but observed concentrations rarely exceed 30 mg/l. Special Protection Waters policy may be applied to create more stringent natural water quality targets. Similar parameters include TDS, maximum turbidity, fecal coliforms, dissolved oxygen, and nitrates. In some cases, as with nutrients, no DRBC criteria currently exist and effect levels of nutrient concentrations in the Delaware River are unknown at this time. Even if effect levels were known, we do not know what concentrations or loadings represent natural background conditions or human enrichment. Establishment of EWQ targets in these cases would ensure that nutrient pollution does not become worse – we need only to look at the Chesapeake experience as an extremely expensive example of nutrient enrichment consequences and large-scale abatement efforts that may or may not succeed.

Delaware River Biomonitoring Results

Biological integrity and habitat quality are two directly measurable aspects of ecological condition. Only the first season's results of the Delaware River Biomonitoring Program were available for this evaluation. There are not yet sufficient data to evaluate variability or trends. Sufficient data exist to compare Lower Delaware biological scores against known reference conditions. When DRBC Special Protection Waters rules were enacted in the early 1990's, three biological metric targets were included in the definition of EWQ: Shannon Wiener Diversity; Equitability; and EPT Richness. In the late 1990's, equitability was found to be an unresponsive indicator of changes to biological integrity. DRBC biologists are presently refining a list of macroinvertebrate community metrics that respond best to water quality changes in the Delaware River.

Lower Delaware biological diversity and taxonomic richness scores from 2001 were compared with exceptional quality Middle and Upper Delaware River biological targets from DRBC's water quality rules. Healthy macroinvertebrate assemblages score higher in diversity and EPT richness than stressed assemblages. Lower Delaware macroinvertebrate data were also compared with New Jersey's most stringent pollution tolerance criterion (Hilsenhoff Biotic Index score of 4.0). The lower the Hilsenhoff score, the better and less tolerant of pollution is the macroinvertebrate assemblage. Results are positive though not definitive due to small sample size. Delaware River biocriteria development is underway with assistance from the U.S. EPA.

Desirable and measurable traits of habitat quality were examined, including parameters listed in the U.S. EPA Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers (Barbour et al., 1999). Not all of the Rapid Bioassessment Protocol's habitat parameters translate well to large rivers, but parameters that do so include substrate heterogeneity and stability; heterogeneous flow and depth regimes, sediment deposition indicators; channel flow status; bank stability and vegetative protection; and overall habitat complexity and cover. Even in low flow periods the Lower Delaware received optimal habitat scores at every site. Such evidence indicates that the Lower Delaware possesses exceptional habitat conditions for aquatic life.

Preliminary benthic macroinvertebrate results suggest that that the biological community of the non-tidal Lower Delaware River is exceptional and appears worthy of Special Protection Waters designation. Lower Delaware benthic community data collected during August-September 2001 compared favorably with existing targets for the Special Protection Waters of the Upper Delaware River. Because biocriteria do not currently exist for the Lower Delaware, the Upper Delaware's most conservative thresholds were used. Results indicate

that Special Protection Waters protection is appropriate, since the Lower Delaware River largely scored as well as or better than target values set for waters already so designated.

The Shannon-Wiener Index measures diversity of the macroinvertebrate assemblage. Limited results suggest that the Lower Delaware River possesses a highly diverse macroinvertebrate assemblage, meriting SPW status. The Hilsenhoff Biotic Index value was calculated for each sample and then compared against the strictest criterion. New Jersey's HBI of 4.0 is their threshold for intolerance. Results suggest that the Lower Delaware River's benthic macroinvertebrate assemblage is intolerant of pollution, indicates excellent water quality, and merits SPW status. At all but 2 sites, the Lower Delaware biological community met the Upper Delaware EWQ target of 15.5 for the presence of Ephemeroptera, Plecoptera, and Trichoptera taxa (EPT), a measure of richness of the most pollution sensitive taxa in aquatic systems. Results indicate that the Lower Delaware River benthic macroinvertebrate assemblage is very rich in pollution intolerant genera; to such a degree that EPT taxa often dominate macroinvertebrate samples taken from the Lower Delaware. This indicates excellent water quality, and supports SPW status.

Lower Delaware River Water Quality Changes from Portland to Trenton

In general, smaller tributaries (Pidcock, Paunnacussing, Tinicum, Lockatong, Wickecheoke, Nishisakawick) had no measurable effects upon Delaware River water quality. Even where small tributary concentrations of water quality constituents were significantly higher or lower than the Lower Delaware, no overall effect could be detected at neighboring Interstate Control Points. This is due to the tributaries' small flows relative to the Delaware River. Three small tributaries (Pidcock, Wickecheoke, and Lockatong) flow into the canal systems during all but very high flow events. Flow capture by canals reduced effects of these tributaries even more.

Statistically significant changes in constituent concentrations were examined at each Interstate Control Point from Portland downstream to Trenton. **Table 3** lists significant changes (p=.05, or 95% probability that water quality differed from one location to the next) in water quality within each Delaware River segment. Appendix C in the "Lower Delaware Monitoring Program: 2000-2003 Results and Water Quality Management Recommendations " (DRBC 2004) contains a table of all river-to-river segment site comparisons and tributary-to-river site comparisons of median water quality concentrations.

FROM	TO	+/-	PARAMETER
Portland	Belvidere	increase	TDS (+12 mg/l – limestone)
(major tributary between Portland and Belvidere is Paulins Kill)		increase	Alkalinity (+6 mg/l – limestone)
		increase	Enterococcus (+24 colonies/100ml)
		decrease	Dissolved Oxygen Saturation (-3.3%)
Belvidere	Easton	increase	TDS (+20 mg/l – limestone)
(major tributaries between Belvidere and Easton are Pequest River, Martins Creek, and Bushkill Creek)		increase	Hardness (+11 mg/l - limestone)
		increase	Alkalinity (+8 mg/l – limestone)
		increase	Nitrate-N (+0.16 mg/l)
		increase	Total Nitrogen (+0.315 mg/l)
		increase	Fecal Coliform (+65 colonies/100ml)
		increase	Enterococcus (+106 colonies/100ml)
Easton	Riegelsville	increase	TDS (+30 mg/l – limestone)
(major tributaries between Easton and Riegelsville are Lehigh River and Pohatcong Creek)		increase	Hardness (+20.5 mg/l – limestone)
		increase	Alkalinity (+10.5 mg/l – limestone)
		increase	Total Phosphorus (+0.06 mg/l)
		increase	Nitrate-N (+0.355 mg/l)
		increase	Total Nitrogen (+0.190 mg/l)
		decrease	Enterococcus (-83 colonies/100ml)
FROM	**TO**	**+/-**	**PARAMETER**
Riegelsville	Milford	increase	Total Nitrogen (+0.145 mg/l)
(major tributaries between Riegelsville and Milford are Musconetcong River and Cooks Creek)		decrease	Enterococcus (-19 colonies/100ml)
		decrease	Fecal Coliform (-26 colonies/100ml)
Milford	Bulls Island	increase	Dissolved Oxygen Saturation (+2.4%)
(major tributary between Milford and Bulls Island is Tohickon Creek)		decrease	Enterococcus (-16 colonies/100ml)
Bulls Island	Lambertville	decrease	Dissolved Oxygen Saturation (-4.97%)
(no major tributaries in reach except wastewater dischargers)		increase	Chloride (+3.7 mg/l)
		increase	TKN (+0.160 mg/l)
		increase	Total Nitrogen (+0.203 mg/l)
Lambertville	Washington Crossing	increase	Dissolved Oxygen Saturation (+4.11%)
(no major tributaries in reach except wastewater dischargers)		decrease	Chloride (-2.7 mg/l)
		decrease	TKN (-0.110 mg/l)
		decrease	Total Nitrogen (-0.070 mg/l)
Washington Crossing	Trenton	increase	TKN (+0.130 mg/l)
(no major tributaries in reach except wastewater dischargers)		increase	Fecal Coliform (+28 colonies/100ml)

Table 3. Significant Changes in Concentrations of Water Quality Constituents Between Interstate Control Points of the Lower Delaware River, 2000-2003. Red represents degradation and Blue represents improvement between river sites.

Water Quality Ranking of Sites by Designated Use

DRBC's Integrated Listing Methodology (2004) identified specific water quality parameters associated with each designated use being assessed. The assumption was made that if criteria are met for parameters associated with designated uses, then the designated use is met. Perception of water quality in the Delaware River and its tributaries is dependent on the perspective of the designated use being examined. The relationship of Delaware River quality to its major tributaries (**Table 4**) was examined in terms of general water quality, nutrient quality, water supply quality, aquatic life water quality, and recreation-related water quality.

General Water Quality:	Average of nutrient; recreation; water supply; aquatic life scores
Recreation Quality:	E. coli; Fecal coliform; Enterococcus geometric mean (col/100ml)
Water Supply Quality:	TDS mg/l; Turbidity NTU; Chloride mg/l; Specific Conductance umhos/cm
Aquatic Life Chem.Quality:	DO; pH; Water Temp; TDS load lbs/day; Alkalinity; Turbidity; Specific Cond.
Nutrient Quality:	Total Phosphorus concentration (mg/l), and load per sq.mi. (lbs/sq.mi.) Total Nitrogen concentration (mg/l), and load per sq. mi. (lbs/sq.mi).

Average Ranks of Designated Use Scores

Site	General Water Quality	General WQ Rank	Recr Quality	Recr Rank	Water Supply Quality	Water Supply Rank	Aquatic Life Chemistry	Aquatic Life Rank	Nutrient Quality	Nutrient Rank
207.40 Delaware @ Portland	**4.6**	1	**4.3**	3	**3.0**	1	**6.3**	1	**4.8**	2
197.84 Delaware @ Belvidere	**5.3**	2	**2.7**	2	**4.5**	2	**7.1**	2	**7.0**	3
183.82 Delaware @ Easton	**9.2**	3	**12.3**	7	**6.3**	3	**8.7**	3	**9.3**	5
157.00 Tohickon	**11.0**	4	**14.7**	11	**12.8**	10	**14.4**	10	**2.0**	1
134.34 Delaware @ Trenton	**11.1**	5	**4.3**	3	**11.0**	6	**12.4**	5	**16.5**	14
141.80 Delaware @ Washington Crossing	**11.2**	6	**2.3**	1	**13.3**	11	**12.9**	6	**16.3**	11
148.70 Delaware @ Lambertville	**12.1**	7	**9.3**	6	**11.3**	7	**10.9**	4	**17.0**	15
174.80 Delaware @ Riegelsville	**12.4**	8	**12.7**	8	**10.0**	4	**13.0**	8	**13.8**	8
207.00 Paulins Kill	**14.1**	9	**7.3**	5	**23.0**	18	**18.1**	14	**7.8**	4
167.70 Delaware @ Milford	**14.2**	10	**17.3**	14	**12.0**	8	**13.1**	9	**14.5**	9
155.40 Delaware @ Bulls Island	**14.6**	11	**16.7**	12	**12.3**	9	**12.9**	6	**16.3**	11
173.70 Cooks	**15.3**	12	**25.0**	17	**10.0**	4	**15.9**	12	**10.3**	6
197.80 Pequest	**16.6**	13	**13.3**	9	**21.0**	15	**20.4**	18	**11.8**	7
190.58 Martins	**17.7**	14	**16.7**	12	**16.8**	12	**14.9**	11	**22.3**	17
183.66 Lehigh	**17.7**	15	**14.0**	10	**18.0**	13	**16.6**	13	**22.3**	17
174.60 Musconetcong	**19.4**	16	**21.7**	15	**21.3**	16	**18.1**	14	**16.3**	11
177.40 Pohatcong	**20.1**	17	**25.3**	18	**20.3**	14	**18.7**	16	**16.0**	10
184.10 Bushkill	**20.5**	18	**23.0**	16	**21.3**	16	**20.1**	17	**17.5**	16

Table 4. Average Scores and Relative Ranks of Designated Use Indicators. Low scores are best water quality.

In **Table 4**, each parameter was ranked at each site. Scores represent average ranks of parameters listed above. Each site was then ranked by the average parametric ranks.

In terms of **general water quality**, all Delaware River sites scored better than tributaries, with only the Tohickon Creek and Paulins Kill among the best sites. The worst general water quality streams are Bushkill Creek, Pohatcong Creek, and the Musconetcong River. **Recreation quality** scores show that the highest overall bacteria concentrations were found in Pohatcong, Cooks, Bushkill, and Musconetcong. Scoring best in recreation quality scores were all of the Delaware River sites except for Milford and Bulls Island, and Paulins Kill, Pequest, Lehigh and Tohickon Creek. Only the Lehigh River, however, contained similar or lower bacteria concentrations than the Delaware River. **Water supply quality** results show that the upstream

Delaware River sites are best (Portland, Belvidere, and Easton). Tohickon Creek and Cooks Creek are the best tributaries, scoring among the Delaware River sites. The lowest scoring water supply quality sites are the Paulins Kill, Bushkill Creek, Musconetcong, and Pequest. Limestone effects upon TDS and specific conductance heavily influenced water supply scores. Scoring best in **aquatic life chemistry** are all of the Delaware River sites, followed by Tohickon, Martins Creek, and Cooks Creek. The worst aquatic life chemistry scores went to the Pequest River and Bushkill Creek. Note that this is only a water chemistry index, as no direct biomonitoring results are incorporated into the index. Most investigators would prefer a directly measured biological score to this inferential aquatic life chemistry score. For **nutrient quality**, the Lehigh River, Martins Creek, and Bushkill Creek are the worst. Tohickon Creek, Cooks Creek, and the Paulins Kill River impart the least nutrient impacts upon the Delaware River, though Cooks and Paulins Kill River median concentrations are still significantly higher than neighboring Delaware River sites. Only Tohickon Creek actually improves the Delaware River in terms of nutrient loading, possibly because of Lake Nockamixon acting as a nutrient sink. Delaware River results were mixed, with the upper sites (Portland, Belvidere, and Easton) scoring well and the rest toward the middle and lower ends of the ranking scale.

Prioritization of Watersheds for EWQ Maintenance or Restoration

There are no sites where water quality should be strictly maintained or restored for every parameter. **Table 2** shows where and for which parameters maintenance or restoration of water quality should occur. **Table 4** shows how Delaware River water quality relates to its tributaries. Delaware River water quality is as good or better than even state designated antidegradation waters for most uses. For this reason, it is recommended that the Delaware River should be declared Outstanding Basin Waters in Scenic and Recreational River designated segments, and Significant Resource Waters in undesignated segments. In the Delaware River, recreation quality must be improved at Milford and Bulls Island, and nutrient quality should be improved from Riegelsville to Trenton. Intrastate priority watersheds (**Table 5**) were determined according to designated uses to be protected, as well as relative effects upon the Delaware River.

Table 5. Priority watersheds tributary to the Lower Delaware River.

Water Quality Management	General Water Quality	Recreation Quality	Water Supply Quality	Aquatic Life	Nutrients
Protect	Tohickon	Lehigh	Tohickon	Tohickon	Tohickon
	Paulins Kill		Cooks	Martins	
				Cooks	
Restore	Bushkill	Pohatcong	Paulins Kill	Pequest	Lehigh
	Pohatcong	Cooks	Bushkill	Bushkill	Martins
	Musconetcong	Bushkill	Musconetcong		Bushkill
		Musconetcong	Pequest		

Maintenance of EWQ can be done using antidegradation policy, cooperative and adaptive management, long term monitoring, corrective or protective action, and periodic re-evaluation of site-specific targets. Restoration of water quality has historically been a high priority to DRBC and the states, conducted through numerous programs and TMDL activities. Improved coordination between DRBC, the states, and watershed organizations will be necessary to achieve protective or restorative goals.

Risks Associated With Water Quality Degradation

In water resources, the need to protect supply and quality is exceptionally important. This is especially true in urbanized or growing areas that are not as easily protected as forested headwaters. Wherever people live, even 'average' water quality may prove to be of exceptional value. Arguably it should not be necessary for water quality levels to exist above some extremely high threshold for designation of SPW to occur. In principle it is certain that all users demand and deserve the cleanest possible water.

What's so 'special' or 'exceptional' about the Lower Delaware? In measures of water quality and biological integrity, the Delaware River is better than the state designated HQ, EV, and C1 waters in most cases. The magnitude of importance of meeting designated uses is certainly of exceptional value in the Lower Delaware, since the resource is so intensively used. Even though more people live in the Lower Delaware, placing these waters more at risk than those of the Upper Basin, direct comparison of biological scores revealed that the Lower Delaware is every bit as healthy as the cleanest upper basin waters.

Degraded water quality in the Lower Delaware means worse quality water and more expensive supply for Central and Southern New Jersey; Bucks, Montgomery, and Philadelphia Counties in Pennsylvania, and points south. Even though water quality of the Lower Delaware shows bacteria problems, it may be 'exceptional' based on all the other parameters that are better than standards.

Concerning water quality that does not meet standards, what are the risks associated with degradation? We can assume the following statements are true as common knowledge. Clean water is safe and economically beneficial. It costs little to treat, and extends the life of treatment infrastructure. Corporations want to locate where water is clean and plentiful. Recreation is a positive experience. Tourism and environmental education benefits are provided in riverside towns like Lambertville and Easton that hold festivals featuring the river. Quality of life is tied closely to quality of water. Waterfront homes are highly valuable where the water quality is good. Clean water is taken for granted. If water quality got worse, negative effects would be felt in terms of rising treatment costs, expenses related to delivery of alternative water supply sources, increased incidence of waterborne illness, increased trash, nuisance vegetation and decaying organic matter, stresses to aquatic life, loss of riverside home value, and loss of recreation and tourism economic benefits. Even water that meets minimally acceptable criteria may be associated with some of these negative results if existing water quality is not protected.

Expected Effects of Waste Water Dischargers and Stormwater Upon EWQ

Appendix E of the "Lower Delaware Monitoring Program: 2000-2003 Results and Water Quality Management Recommendations " (DRBC 2004) technical report contains an inventory of municipal, institutional, and industrial wastewater dischargers of over 100,000 gallons per day to streams in the Lower Delaware watershed. The wastewater from these facilities is included in the definition of existing water quality, and these facilities as permitted would not be subject to additional treatment requirements set forth in DRBC's water quality rules for Special Protection Waters. Only new and expanded discharge facilities would be subject to such rules. **Figure 1** displays the locations of selected dischargers of over 1 million gallons per day and/or direct dischargers to the Delaware River. These are shown relative to the location of DRBC monitoring locations and designated Scenic Rivers segments. In terms of average monthly wastewater effluent flow during the 2000-2003 study period, Pennsylvania dischargers operated at 71% of their overall permitted flow, and New Jersey dischargers operated at 66% of their overall capacity.

Existing water quality might or might not measurably change if all of the permitted dischargers increase their effluent rate to 100% of their capacity. As defined during the 2000-2003 study period, existing water quality reflects a very broad range of discharge situations from extreme low flow conditions to relatively high flow conditions, when most dischargers operated at effluent flow rates far beyond normal flow rates. Thus, the statistical definition of existing water quality includes such cases of high flow events. Under such conditions

the dischargers achieved their permitted water quality limits without permit violations or severe increases in the rate of pollutant loading to the Delaware River. A few treatment facilities continue to experience infiltration and inflow (I and I) problems related to storm events, which forces the facility to treat stormwater in addition to sanitary sewage flow. Maintenance of I and I is an excellent step toward ensuring that existing water quality is maintained or improved.

Of much more concern is non-point source water pollution, or that caused by stormwater runoff. The increase in non-point source pollution associated with future growth and development is very likely to measurably change existing water quality if it increases unmanaged. It is expected, however, that existing water quality will continue to improve even as the wastewater treatment facilities grow toward their full capacity. New stormwater rules and policies are taking effect in New Jersey and Pennsylvania, efforts to improve riparian buffer zones continue to grow and evolve, residential and business stormwater management practices are improving, and education of municipal officials and the general public on stormwater issues is becoming more widespread. These powerful tools improve water quality and allow for growth and development.

To ensure that existing water quality is maintained or improved, the control point monitoring approach should be used to document cumulative effects of combined point source and non-point source water management. The water quality targets at Boundary Control Points (final targets will be defined using the 2000-2004 data set) must not be exceeded, or the water quality of the Delaware River will degrade. Conversely, the targets may also be used as a reference to quantify trends and improvements in water quality resulting from combined efforts to manage dischargers and non-point source pollution in each watershed.

Lessons From Upper and Middle Delaware SPW

Three unanticipated flaws became apparent with attempts to implement Special Protection Waters rules in the Middle and Upper Delaware in the 1990's. The first, as previously mentioned, was the technical difficulty with detecting measurable change using reachwide targets. It required years of baseline monitoring to gather sufficient data for assessment of 'measurable change.' Once enough data were collected, the resolution and statistical power of the data were poor (Evans et al., 2000). Water quality changes may have occurred with no mechanism for timely reaction by DRBC or the states. The LDMP solved this assessment issue by creating site specific EWQ targets instead of reach wide EWQ targets. No two spots on the river are exactly alike, so why should the targets be averaged?

Lack of cooperation between partners was a second failure. Chief among the many reasons was a lack of clear commitment and delineation of financial, management, monitoring, and assessment responsibilities between partner agencies. In the Middle and Upper Delaware, the National Park Service has monitored the Delaware River and its tributaries since 1992 without direct DRBC support. The NPS recently contracted with the U.S. Geological Survey to collect water quality data for DRBC Boundary Control Points. In support of DRBC mandates, the National Park Service units continue to commit significant portions of their resource management budgets to monitor and protect water quality. DRBC should support these efforts.

A third and smaller problem internal to DRBC has been the programmatic and budgetary separation of the Upper, Middle, Lower and Estuary monitoring programs for the Delaware River. When DRBC shifted interest from the Upper/Middle to the Lower Delaware, its staff began participating with the planning committee, monitoring water quality, and envisioning SPW protection of yet another reach of river (before the Upper and Middle Delaware SPW implementation was completed and fully tested). The LDMP became a monitoring program separate from the existing Scenic Rivers Monitoring Program (SRMP) and essentially a competitor for limited monitoring funds and staff resources. This contributed to diminution of DRBC efforts in the Upper and Middle Delaware, and delayed implementation of important pieces of SPW rules such as development of Boundary Control Point EWQ targets. At least a decade past the expected date, the states have not received EWQ targets useful for prevention of measurable change in the Delaware River. In the same period, evidence suggests that measurable change may have occurred at locations including the Tri-State region between the

Upper and Middle Delaware; Callicoon Creek; Bushkill Creek, and Brodhead Creek.

Due to the three problems mentioned above, SPW antidegradation policy has not been as effective as it might have been. On a positive note, the project review responsibilities of DRBC were functional during the first ten years of Special Protection Waters. If SPW rules are to be successfully implemented in the Lower Delaware, several steps must be taken. First, all partners must commit to responsible action via formal interagency agreements and sufficiently funded programs. Second, Upper Delaware, Middle Delaware, and Lower Delaware water quality monitoring programs must be consolidated and managed more holistically to reduce competition and increase efficiency by combining the shared efforts of DRBC, NPS, and state agency staff. Additionally, EWQ assessment should be conducted in parallel with the 305B assessment**,** so staff resources may be further shared to reduce assessment redundancy and create consistency in reporting of results. Third, all watershed partners must be made aware of and versed in the use of Boundary Control Point water quality targets to report measurable results of their efforts to improve water quality. DRBC and partner organizations should contribute significant resources to education, capacity building of watershed organizations, and creation of guidance on implementation of SPW rules and targets.

Thus far, the Lower Delaware Monitoring Program has been cooperatively managed by dedicated and talented local residents and agency staffers. Federal, state, local, and regional partners are represented on the management committee. Early in the process of creating the monitoring program, DRBC was assisted and directed by a technical committee of scientists and managers from all concerned agencies. Successful implementation of Lower Delaware Special Protection Waters will depend on DRBC's ability to direct and/or monitor efforts of many partners within tributary watersheds in order to meet EWQ targets. Reallocation of DRBC staff resources may be necessary to market the effort to maintain or improve water quality of the Lower Delaware, coordinate and monitor progress of local restoration projects and watershed plans, and to widen involvement between agencies, local governments, and watershed organizations. On the technical side, DRBC should create a water quality model to determine causes and effects of water quality changes, develop scenarios for accomodation of future growth while maintaining EWQ, and identifying the most effective means of protecting and improving water quality in the Lower Delaware region. Monitoring should be conducted at a frequency sufficient to determine measurable changes in water quality at ICP and BCP locations. Additional technical actions are noted below.

Recommendations to Commissioners

Recommendation 1. Designate & Implement Special Protection Waters

Where the Scenic Rivers legislation designated segments of the Delaware River, Outstanding Basin Waters should be applied where feasible. The segments in-between and those pending Wild and Scenic Rivers Act designation should be declared Significant Resource Waters. Final SPW targets should be adopted using the 2000-2004 data set. A sample of site specific targets (based on the 2000-2003 data set) is shown in **Appendix D**. Interim targets are not recommended because final targets will be available by the end of 2004.

Recommendation 2. Protect or Restore Priority Watersheds (Table 5, page 17)

Recommendation 3. Build Watershed Partnerships

- Memoranda of understanding with states and NPS
- Capacity building with non-governmental organizations
- Monitor and coordinate water quality actions and plans in the Lower Delaware region
- Create and market guidance for maintenance and improvement of EWQ
- Strategies to maintain and protect water quality for water suppliers

Recommendation 4. Fill Critical Information Needs

- Understand canal-river relationships
- Perform cause and effect surveys within river reaches
- Quantify effects of nutrients and primary production on water quality
- Manage nuisance vegetation and invasive species

Recommendation 5. Consider Changes to Water Quality Rules

- Introduce nutrient and/or eutrophication criteria
- Create numeric aquatic life biocriteria for macroinvertebrates
- Revise Middle and Upper Delaware reach wide EWQ targets to site-specific targets.
- Introduce bacteria standards for non-tidal river
- Adopt Pennsylvania warm water temperature standards for protection of aquatic life
- Consider raising pH upper limit to 9 instead of current 8.5
- Consider raising TDS limit above Easton to reflect natural limestone influences
- Raise minimum Dissolved Oxygen to 5.5 mg/l in Zones 1D and 1E.

Recommendation 6. Support Monitoring to Meet Recommendations

- Add ICP sites between major tributaries for improved cause-effect resolution.
- Continuous monitors at Belvidere, Riegelsville, Paulins Kill. Maintain existing monitors.
- Reduce frequency of DRBC monitoring of minor tributaries
- Maintain frequency of monitoring for ICP and major BCP sites.
- Streamline and make concurrent EWQ assessment and 305B assessments
- Rotate synoptic surveys of minor tributaries for compliance monitoring
- Combine Upper, Middle, Lower Delaware monitoring programs into Scenic Rivers Program.
- Support EWQ monitoring of major tributaries and ICP locations from Hancock to Trenton.
- Create water quality model to serve planning for protection or restoration of water quality.

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